On our Knowledge of Markets for Knowledge—A Survey

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1. Introduction

At the Lisbon Summit 2000 the EU set herself the goal of transforming the European Union by 2010 into "the most competitive and dynamic knowledge based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion". I take this statement as a starting point for this paper for two reasons: On the one hand it acknowledges the crucial role of knowledge in an advanced economy. On the other hand, it raises the question what needs to be done in order to achieve this ambitious goal. In particular, since the EU is also committed to a market economy and the maintenance of competition the question arises how well markets function with respect to the creation and distribution of knowledge, and what measures may be required, either to support the market mechanism or to replace it by some other institutions.

This article deals with the first question and offers a survey of the problems encountered in markets dealing with knowledge. In the next section I discuss briefly the role of knowledge and information in economics. After that I point out a few difficulties with finding a precise and generally accepted definition of knowledge. Section 4 is the core of the article and discusses various types of market failures which might occur when the commodity produced and traded is knowledge. I conclude with a few suggestions for further research.

2. The role of knowledge and information in economics

Knowledge and information deserve a central role in economics for at least three reasons:

1) In advanced economies the information sector contributes around 50% to Gross Domestic Product, and it has been the fastest growing sector over the last twenty years.
2) Research, development and innovations are main contributors to econom-

ic growth and explain up to 50% of the increase of labor productivity.
3) Accounting for information poses a major challenge to economic theory in almost all of its branches.

Even though there is now general agreement about the importance of knowledge and information it took some time before this was fully reflected in economics, both at a theoretical and at an empirical level. It is remarkable that "Austrian" economists who were contemporaries of Wittgenstein were among the pioneers in this area.

Fritz Machlup was the first to point out the growing importance of the "creation and distribution of knowledge" (Machlup 1962, 1980) and is considered as "one of the fathers of thinking about what has come to be labeled the information society and the information economy." (www.caslon.com.au/biographies/machlup.htm).

Joseph Schumpeter realized very early the crucial role of innovations for economic growth and introduced the famous concept of "creative destruction" into economics. While his ideas have been neglected in mainstream—i.e. neoclassical—economics for a long time they are now widely believed to be the most solid foundation for both, theory and policy of economic growth (Aghion and Howitt 2005).

Friedrich von Hayek, a nephew of Ludwig Wittgestein's mother, insisted for a long time that a market economy is superior to a centrally planned economy because it is much more efficient with respect to the creation and utilization of social knowledge, which is scattered in a society and can never be efficiently centralized (Hayek 1945). Ironically, later research which was at least partly inspired by Hayek has shown that markets are far less efficient when it comes to creating and distributing knowledge or information than he apparently believed (e.g. Grossman and Stiglitz 1980), though he appears to have been correct with respect to the still greater inefficiency of central planning. It is the main theme of this paper to discuss problems and shortcomings of markets when it comes to dealing with knowledge and information. It is worth mentioning, however, that the problems associated with knowledge and information as commodities are only a comparatively small part of the problems that are dealt with in the so called economics of information (see Stiglitz 2001).

3. Some definitions

So far we have treated knowledge and information as synonyms and refrained from offering a precise definition of either. There are several good excuses for this:

Consulting dictionaries or encyclopedias does not get us very far. In the most popular source of wisdom for the internet generation we learn that "knowledge is defined (*Oxford English Dictionary*) variously as (i) facts, information, and skills acquired by a person through *experience* or *education*; the theoretical or practical understanding of a subject, (ii) what is known in a particular field or in total; facts and information or (iii) awareness or familiarity gained by experience of a fact or situation (Wikipedia)." Actually, in my version of the Oxford Advanced Learner's Dictionary the word "facts" is replaced by "understanding". In any case, looking at various dictionaries makes one feel even worse than Chruchill when dealing with economists. He once complained that when asking three economists one gets four opinions, two of them from Mr. Keynes. Looking at three dictionaries one would be happy to get just four definitions of "knowledge". In fact, the one I liked best can be found in the *Webster Handy College Dictionary*, where knowledge is defined as "awareness of facts, truths, or principles; a body of accumulated facts". Interestingly, it was the only source I found where "knowledge" and "information" are not treated as more or less synonymous.

No wonder that one of the current pundits of the information society noted, "the distinction between information and knowledge is a tricky one" (Benkler 2006, p.313). I am not sure whether his own definition is really satisfactory: "[he uses] information … colloquially, to refer to raw data, scientific reports of the output of scientific discovery, news and factual reports. "Knowledge" refer[s] to the set of cultural practices and capacities necessary for processing the information into either new statements on the information exchange, or more important in our context, for practical use of the information in appropriate ways to produce more desirable actions or outcomes from action" (Benkler 2006, p.313).

Machlup (1962), who attempted to measure the magnitude of the production and distribution of knowledge distinguished five types of knowledge:

- practical knowledge,
- intellectual knowledge,
- pastime knowledge,
- spiritual or religious knowledge,
- unwanted knowledge, accidentally acquired and aimlessly retained.

Curiously, he included the distribution of typewriters and stationery as part

of this knowledge industry. In any case, the distinction between knowledge and information is again somehow blurred.

Another eminent economist of this generation, Kenneth Boulding, made the following observation: "There is a little terminological problem here, that the word "knowledge" in English has some tendency to approach the meaning of "truth". We have really no convenient word to describe the content of the human mind without regard to the question as to whether this cognitive content corresponds to anything outside it. For this reason I have in the past used the term "image"… I will revert to the term "knowledge" with a warning that I make no assumption about the content of people's minds being true". (Boulding 1966, p.1).

I am afraid that I cannot get any further than this, and I hope that for my purposes it is not necessary to do so. I shall use "information" and "knowledge" as synonyms, unless stated otherwise, and I follow Boulding: "I shall become very pragmatic at this point and consign the philosophical problems to my esteemed colleagues who make this their specialty, and I shall assume simply that knowledge exists" (Boulding 1966, p. 2). And, I might add, even though we may not be able to define knowledge in a precise way, we recognize it when we encounter it, at least when discussing it in the context of markets for knowledge.

4. Knowledge as a commodity and market failures

4.1 The first welfare theorem

One of the most remarkable achievements of economics in the 20st century was the so called "general equilibrium theory" and its welfare theorems. The main result of the "Arrow-Debreu-Model" is that in an economy with a complete set of perfectly competitive markets an equilibrium exists and is Pareto-efficient, i.e. there is no waste (Arrow and Debreu 1954). It would be quite misleading, however, to take this result as a proof for the overall efficiency of a (capitalist) market economy. In fact, quite the contrary is true since the conditions for this result to hold are listed meticulously, and it is quite obvious that they are extremely unlikely to be satisfied in any real world economy. If one or more of these conditions are violated efficiency of an equilibrium (if one exists) is no longer guaranteed and we get what has been termed market failure. Now the occurrence of market failures does not necessarily mean that free markets are inferior to other ways of organizing

economic activities, but at least they make it worthwhile to think about alternatives.

The main causes of market failures are market power, externalities, public goods (for definitions see below) and various forms of imperfect information. What is remarkable for our topic is the fact that knowledge as a commodity is very likely to induce all these traditional causes of market failures (Allen 1990) and, as if this were not enough, add a few more not encountered with other commodities. In what follows I shall discuss some of these market failures in markets for knowledge in more detail. For the sake of completeness I should like to add that of course not all types of knowledge will under all circumstances display all or even one of the causes for market failures. The claim is rather that for each type of market failure one can find some type of knowledge leading to this market failure.

4.2 Knowledge and market power

Knowledge and (market) power may be linked in various ways, and I shall confine myself to discussing two aspects:

4.2.1 Economies of scale and scope

A main reason for the existence of big firms who obviously have considerable market power are economies of scale and scope, i.e. the fact that it is less costly to produce given volumes of outputs within one large corporation rather than in many small independent firms. One reason for this phenomenon, which is also referred to as "sub-additivity of costs" is the existence of large fixed costs which have to be incurred regardless of the volume of output.

A moment's reflection shows that such economies of scale and scope are likely to exist in the production of many types of knowledge. Consider the compilation and processing of huge amounts of data. There are large fixed costs for setting up the appropriate hardware, and similarly one needs flexible and powerful software. In comparison the costs of using both for the generation of information by feeding in data are small.

Or think of University departments. Certainly in economics, but I suspect Philosophy is not so different, a critical mass of researchers with some variety of expertise is needed in order to achieve success and make it to the upper segments of rankings. It is not just economies of scale—the bigger,

the better—but also economies of scope that can be utilized: If various lines of research and expertise can be combined the chances for new and relevant results will improve.

Whether economies of scale and scope will actually translate into market power depends on the appropriability of the knowledge generated. As I shall discuss in some detail below knowledge very often cannot (and quite frequently should not) become the private property of anyone. With basic scientific research as conducted in universities this is pretty obvious. But of course there exist other types of knowledge with a large potential for profitable commercial use. It is knowledge that allows the production of known goods at lower costs or of new or better goods. An economic agent in possession of such knowledge can use it in two—not mutually exclusive—ways: She can either use it for producing and selling goods herself, thus selling knowledge indirectly embodied in her products, or she can sell the knowledge to somebody else. As we shall see below the second option has several difficulties, but for the moment I would like to concentrate on the first one.

4.2.2 Arrow's dilemma

Now suppose somebody has succeeded in creating knowledge that could be used in a commercially profitable way. If she retains exclusive possession of this knowledge then she obviously has a monopoly implying a socially inefficient use of productive resources in the short run: In order to exploit her monopoly she will produce less than the social optimum and charge a price above marginal costs. The first welfare theorem would require that her knowledge becomes available to everybody in order to ensure perfect competition. However, if the creation of profitable knowledge is costly and risky, who would ever bother to engage in such activities if she is forced to give away her knowledge immediately after she gets it? So here we have a problem pointed out by Arrow back in 1962: There is a conflict between short run efficiency which would require that socially useful knowledge becomes accessible to everybody, and long run efficiency which would require that economic agents are willing to make the investment and take the risk of creating such knowledge because they will be able to enjoy a handsome return by exploiting a (temporary) monopoly profit (Arrow 1962). Needless to mention that the problem has not been solved yet—and presumably never will be. Ongoing debates about intellectual property rights, patents, copy rights and open source are a clear indication that Arrow's dilemma has not lost its importance, though it has come up in different guises.

4.3 Knowledge and externalities

One of the currently most popular introductory text books in economics offers the following definition: An "externality arises when a person engages in an activity that influences the well-being of a bystander and yet neither pays nor receives any compensation for that effect" (Mankiw 2005, p.204). In this dramatic age of global climate changes we associate with externalities usually negative effects like the pollution of water and air or the emission of greenhouse gases. New knowledge, respectively its use, however, very often causes positive externalities. Suppose again that an entrepreneur has made an innovation, say discovered a new technology that enables him to reduce the (marginal) costs of production drastically—meaning she enjoys a monopoly. Of course she will make a very handsome profit, but consumers will benefit as well: In order to maximize her profits the innovator will pass on part of the cost reduction to consumers. This affects their well-being, but they do not compensate the entrepreneur fully—they enjoy a positive externality. But there may also be other beneficiaries: Consumers who need less of their income for buying the good will increase their demand for other goods—especially if they are complements of the good that has become cheaper. Alternatively, the innovation may reduce the costs of production or the quality of other goods—the progress that has been made with respect to electronic equipment has revolutionized the production of many other goods. In short, even if the new knowledge remains exclusively with the innovator positive externalities will be created with the effect that the private return to the innovation is considerably smaller than the social one. There exist various estimates of private and social returns to research and development, and while the absolute figures differ due to different methods of measurement the ratio of social to private returns is remarkably stable: it is about 2:1 (Griliches 1995). As a consequence, we have a market failure: private entrepreneurs tend to spend less on R&D than would be socially optimal. In fact, this is a market failure most industrialists and their lobbies are quite happy to admit, since it is used—quite successfully—as an argument for obtaining subsidies.

As I shall discuss below, things are not always that simple, and there are circumstances under which there is too much, or rather misdirected private R&D investment. But let me pursue a bit more the problem of insufficient generation of knowledge in a market economy. So far we have only discussed the occurrence of externalities without any direct use of the new knowledge by other economic agents. In many instances it is inevitable to give away at least some knowledge the moment it is actually used. Think for

example of the pharmaceutical industry. If a certain approach has turned out to work for some problem one can infer that it is quite likely to work at least for related problems.

A similar problem may affect the celebrated—though often doubted—efficiency of financial markets. It is claimed by some economists that financial market are extremely efficient with respect to processing relevant information about the prospects of firms. Now suppose it is indeed possible to obtain information about firms which can be profitably used for transactions in the stock market. The problem is that other market participants can observe the actions of the agents who have obtained the information. This way the information is revealed and therefore is no longer profitable. But if obtaining information is costly then nobody has an incentive to get informed as long as she can get the information for free by observing what the informed agents are doing. So eventually nobody will be informed. But if nobody is informed there is again an incentive to become informed, and no equilibrium exists. This problem, analyzed first by Grossman and Stiglitz (1980) may look very special, but it points to a much more general problem: Using information reveals it at least partly to others and thereby makes it less valuable.

To sum up this section, due to positive externalities which drive a wedge between social and private returns to the creation of knowledge and information markets may produce too little of both.

4.4 Knowledge as a public good

Consulting again Mankiw (2004, p. 225) we find the following definition: ”Public goods are neither excludable nor rival. That is, people cannot be prevented from using a public good, and one person’s use of a public good does not reduce another person’s ability to use it.” Interestingly, basic research, i.e. the creation of knowledge, is mentioned as an important example for a public good, immediately after national defense and before the old textbook favorite, the lighthouse. A distinction is drawn, however, between general knowledge, like a mathematical theorem, and specific knowledge, such as an invention of a better battery. Whereas the latter can be patented and hence exclusion is possible, the former cannot.

In a way this distinction is more apparent than real. The use of specific knowledge is not rival from a purely technical point of view: Your ability to produce a better battery does not affect my ability to do likewise. What is rival, however, is the commercial utilization of this specific knowledge: If we both produce the better battery we compete for consumers and our profits

will go down. Here we are back again at Arrow's dilemma.

While markets are not particularly good at providing public goods—since by definition they are not excludable it is impossible to charge a price for them—it has to be admitted that finding an efficient decision procedure for the determination of the quantities and types of public goods to be produced is not a trivial task.

4.5 Imperfect information about knowledge

A crucial assumption of the Arrow-Debreu general equilibrium model is that all market participants have perfect information about the qualities and prices of all goods offered. Though some introspection reveals immediately that this assumption is wildly unrealistic its importance has been ignored for a long time. Taking into account that the information of market participants is not only incomplete, but also unequally distributed has far reaching implications, which have been surveyed extensively by one of the pioneers of the economics of information, Joseph Stiglitz (2001). In this paper I want to discuss just a few aspects which are relevant when the commodity under consideration is knowledge.

A useful classification of commodities based on the information of the consumer is the following:

1. Inspection goods: The buyer can evaluate the quality of a product on the spot *before* buying it.
2. Experience goods: The buyer learns the quality of a good only by using it, i.e. *after* buying it.
3. Credence goods: The buyer is *never* able to evaluate the quality of the good or service she has bought.

Knowledge as a commodity sometimes belongs to the first category, but very often to the second and frequently to the third. In fact, if it is possible to evaluate the quality of some piece of knowledge before buying it there is a problem for a market to work: In order to be able to determine the value of knowledge for a buyer she needs to know what it is. But once she knows it herself she does not need to buy it. We shall return to this and similar problems in later sections.

Experience goods are more common than one might think at first sight. Whether the car I am buying is of good quality or is what Americans call a "lemon" will only be revealed in the future. Closer to our topic, whether the lecture you are attending or the books you are reading are worth the time and money spent can only be said after you have done it.

Credence goods are often provided by experts offering services of which the buyers cannot say whether they are really necessary and/or whether they have actually been performed (Dulleck and Kerschbamer 2006). Again cars are an example: Most of us cannot really determine whether a particular part has to be replaced and, once we have accepted the advice of the expert, whether it actually has been replaced. Medical treatments often display similar problems, and so do many professional services. Research, i.e. the creation of knowledge, is another example. Very often it is not even possible to tell ex post what the expert has actually done, since the outcome we observe is not only the result of his actions, but also of some random influences. If we are lucky we get away without accident even if the brakes have not been repaired properly, and often we overcome some illness despite the treatment we receive (to be fair, both examples can as well be turned into their opposite).

More generally, in many markets we get asymmetric information: The seller knows more about the quality of the good or service he offers than the buyer. If providing better quality is costly then the seller has an incentive to offer quality which is worse than what he pretends to.

This may have important implications for the functioning of markets. In particular, prices may no longer be adjusted to equate supply and demand, but rather serve as an incentive and selection mechanism. Think of labor markets, and in particular of labor markets for scientists. It is not an easy task to monitor what a researcher in some university department actually does. If we see a scientist at his desk staring into emptiness we cannot really tell whether he is thinking of his girl friend or trying hard to solve a very difficult problem. What we can really observe—at best—is the final result, which depends on three things: the ability of the researcher, his effort, and on his good luck. Now suppose there is an excess supply of researchers. Should universities reduce salaries? If one believes in monetary incentives, the answer even most non-economists will like to hear is no! The reason is that lowering the salaries has two negative effects on the quality of research: There is an adverse selection effect since the most gifted researchers are likely to be able to find better paid jobs elsewhere, and there is a moral hazard problem, since badly paid researchers won't care very much if they are fired for lack of success, hence they have little incentives to exert a lot of effort (Akerlof and Yellen 1986).

Since the recruitment of scientists and the provision of incentives are crucial for the production of knowledge it should be obvious that relying on market forces alone will not do. They have to be supplemented by various other measures like peer reviews, measurement of impact and rankings, but

also by developing a social structure and a value system that induces scientists to do their best. Ongoing debates about university reforms are a good indicator that this is not an easy task.

4.6 Private and social value of knowledge

If markets are supposed to be used to determine the production and distribution of knowledge two conditions are necessary—though not sufficient—to ensure that the outcome is efficient: Economic agents should be able to determine the value of the knowledge they are trading for themselves, and the private and social value of knowledge should be the same. We have already given examples above which show that under a variety of circumstances those conditions are not satisfied, but at this point I would like to discuss this problem in more detail.

4.6.1 Private value of knowledge

It has already been pointed out that knowledge as a commodity quite often can be viewed as an experience or even as a credence good, implying that a buyer does not know for sure the value of what she is about to get, but can only make a more or less informed guess. It has been shown some time ago that the winner of an auction for some object about which the bidders have different information and/or believes may suffer what has been termed as "the winner's curse" (Wilson 1969). It means that it is not unlikely that the person who is willing to pay most is also the most optimistic one with exaggerated expectations. If you look for examples remember some of the UMTS-auctions a few years ago, or think of some transfers in professional football. In any case, the beliefs of individuals about the value of certain objects may lead to rather inefficient decisions and thus impede the smooth functioning of markets.

Interestingly, the private value of information may be negative, even if the information is perfectly correct, i.e. economic agents may be willing to pay if certain information does not become available (Hirshleifer 1971). As an example, suppose there is a village and people know that one of the houses will be destroyed by fire, flood, or some other catastrophe, but they don't know whose house it is. Assume it would be possible to find out at small costs which house it will be. Now if people are risk averse then they would be willing to pay that this information is not obtained because as long as it is

unknown who will be hit by the disaster they would be willing to participate in a mutual insurance scheme. In fact, this example is less far fetched than it looks at first sight. A very similar situation may arise in stock markets, and another example may gain dramatically in importance as early diagnoses of certain diseases become more accurate. As long as I only learn that I will get some disease, but without hope of prevention or cure, I would rather not know about it. In general, less information is often preferred to more if the latter reduces the opportunities for risk sharing.

4.6.2 Private vs. social value of knowledge

It has already been discussed above that knowledge is likely to generate positive externalities thus driving a wedge between the social and private return to knowledge creating activities. Similarly, as far as knowledge is a public good its private value is far below its social value because its use is not excludable.

While in both cases the social value of knowledge is greater than its private value in some cases this relationship is reversed. Consider a so called "patent race": several firms are trying to make a certain innovation, say a new medicine, a new electronic device or what you have. Now for society as a whole it does not really matter whether the discovery is made a few days or even months sooner or later. For those participating in the race, however, it very often makes all the difference to be first or only second, since usually "the winner takes it all". As an example, just recall the battle between different video recording systems: In the end VHS was the only survivor, not necessarily because it was the best system, but because it was the first in the market and had an "installed base" of users which could not be successfully attacked by its competitors. In fact, this was not due to obtaining a patent at first, but because video systems are an interesting example of network goods, a phenomenon we shall return to below. Note that such races are not only found in the commercial sphere, they occur as well in academia. As an example, consider the current race of some leading quantum physicists for the longest distance over which entangled light can be sent or for the first usable quantum computer. Of course I wish my esteemed colleague and friend of the University of Vienna, Anton Zeilinger, that he wins this race. However, without denying in the least the importance of this work, from a social point of view it does not matter all that much whether he succeeds a few weeks earlier or later, though it may be extremely important for him since the reputation—and the financial reward—of being first is disproportionally

greater than of being second.

But it is not only in winner takes it all situations that the private value of knowledge exceeds its social value. Some innovations are hardly improvements as compared to existing best practices and serve only to shift profits from one firm to another. Market guided research may also lead to other inefficiencies. There may be too much duplication of efforts, and coordination of research activities would be socially preferable. A related problem concerns the variety of approaches. It can be shown that under certain assumptions firms tend to pursue very similar research strategies where from a social point of view a diversification would be better. Again this has to do with risk aversion: If I do something similar as my competitor I forego the chance to come up with something truly unique, but I reduce the risk of a complete failure. It may be better to succeed—or fail—in the same way as my competitor than to fail because I tried to do something completely different. Again the situation is often quite similar in Academia: It may be safer to remain within the mainstream without much hope of coming up with something revolutionary (and valuable), but without much risk to be deemed an unqualified failure. The problem is that for the individual researcher it is almost impossible to diversify her lines of research, so if she fails she bears the whole burden alone.

To sum up this section we note that it is often very difficult for a person to determine the value of some piece of knowledge or information; if the private value can be determined it often differs from the social value; and private risk taking may differ from socially efficient risk taking.

4.7 Network effects

A network good has the property that its utility for an individual user is increasing in the number of other users. An obvious example is telecommunication: If there is only one person who owns a telephone its usefulness is quite limited. Many types of knowledge and knowledge goods are characterized by such network effects. The ICT-sector has been the most spectacular and fastest growing network industry, but it is by no means the only one. Network industries have been the subject of extensive research in recent years because they have interesting and important implications for the functioning of markets (Shy 2001).

One of them is the possibility of lock-in effects. As has been shown by Brian Arthur (1989), society may get stuck with an inferior technology, either because it was the first and already had a large number of users—the

so called installed base—by the time a better technology was available, or because it was superior at the beginning for a small number of users and thus got introduced, while a technology that would have been better for a large number of users never got started. An often quoted—though disputed—example is our QWERTY-keyboard. Attacking an incumbent producer of a network good with a strong installed base is quite a risky business, even if a better product is available. Very often there are substantial switching costs—users have to learn how to operate the alternative, i.e. their old knowledge becomes obsolete and has to be replaced by a new one, and this makes it harder to get a critical mass of users necessary to compete with the incumbent. One may speculate at this point how far these considerations apply for Academia when it comes to changing the prevalent paradigm.

Some of the most important network goods, especially computer hardware and software, display crucial complementarities, i.e. consist of several components which are only useful when put together. A computer is useless without operating system, and the operating system by itself is useless without supporting software. Interestingly, it has been shown that under a wide variety of circumstances producers of various components have strong incentives to make their products compatible. The main reason is that making some components compatible softens competition for others. The logic is as follows: Suppose you have two components, hardware and some software. The software is a network good. Now if there are two producers and their machines are not software compatible, i.e. in order to use a machine you have to use the software of its producer, then competition is very stiff because in order to sell the machine I have to ensure a sufficiently large installed base. If both machines are software compatible then the network benefits are the same for both machines and price competition between them becomes weaker.

Similarly, it is in the interest of producers that their operating systems are compatible with as many supporting software products as possible. So it is not surprising that technology sharing and open source are frequently encountered in this sector. At the same time it must be mentioned that in some situations private firms may have a strong incentive to keep relevant knowledge to themselves, even when it would be socially desirable to share it. This is particularly true if the incumbent is or feels strong enough to fight off any entrant.

To sum up this section we note that network effects are likely to produce markets with a dominant incumbent who is difficult to attack once he has established himself. It takes either a far superior product and/or a very strong entrant to be successful. On the other hand, if there are several producers of

comparable strength competition between them may well lead to technology sharing and socially desirable outcomes.

4.8 Trading knowledge

As we have seen when knowledge is regarded as a commodity which can be traded in a market like any other commodity we encounter a number of difficulties which are likely to lead to inefficient outcomes and various types of market failures:

- The paradigm of perfect competition which is at the heart of the first welfare theorem of the Arrow-Debreu model is unlikely to be applicable since economies of scale and scope as well as network externalities more often then not will generate firms with considerable market power.
- Positive externalities, but also winner takes it all situations and business stealing effects drive a wedge between private and social costs and benefits of knowledge. In addition, risk aversion may lead to socially inefficient behavior. Taken together this implies that socially optimal activities for the creation of knowledge are the exception rather than the rule.
- As far as knowledge is a public good there is little incentive for its creation, on the other hand granting patents and intellectual property rights, while providing such incentives, hampers the socially efficient use of knowledge.
- Finally, it is often very difficult to determine the value of knowledge in advance, and often it is not clear what a particular piece of knowledge is actually worth even after one has acquired it. Clearly, this uncertainty does not help markets to perform well.

There is at least one additional difficulty which so far has not been dealt with explicitly. If I sell specific knowledge which can be used profitably I don't actually give it away. If I tell somebody something I know I still know it afterwards. Obviously, this seriously limits the willingness to pay for knowledge. Unfortunately, the effect also works the other way round. If I want to sell specific knowledge I have to tell the potential buyer what it is all about. But once I have told him how can I stop him from using it without paying anything?

To sum up, markets do not seem to do very well when it comes to the creation and distribution of knowledge, and one might understand why economics has been referred to as the "dismal science". However, a few words of caution are in order.

First of all, the benchmark we have used for evaluating market perform-

ance is an extremely demanding one: It is the first best outcome in a perfect world, in which an omniscient and benevolent planner optimizes some well defined welfare function. It should come as no surprise that market outcomes fall short of such an optimum.

Secondly, having shown that markets are unlikely to deliver a first best solution does not mean that there exists another institutional setting which fares any better. Note that many problems we have mentioned are intrinsic problems of knowledge and not of markets, i.e. they will be encountered in any alternative setup as well.

Thirdly, markets and the forces of competition have been remarkably innovative with respect to finding new ways of organizing the production and distribution of goods and services under changing technological conditions. Much has been made of networks and open source, some authors claim that this is a completely new way of organizing the production and distribution of goods, outside and in addition to the traditional forms of firms (hierarchies) and markets (polyarchies) (Benkler 2001, 2006, Powell 1990). While I find these contributions interesting, thought provoking and informative, I also find some of their claims exaggerated. It is beyond the scope of this paper to go into details, but it should be mentioned that markets and firms do play a crucial role in networks. Firms are part of several networks, in fact they are central organizers in some of them; firms have emerged as a consequence of successful open source projects; firms have created open source networks inside themselves; the products of open source networks compete in markets; and several such projects would not be possible without commercial competitors or forerunners. In my view, networks at different levels and with different internal organizations are one, alas an important reaction to some of the problems pointed out above, but in my view they are part of the market economy and they can be fruitfully analyzed and understood with the tools developed in economics (Lerner and Tirole 2002, 2005).

5. Research Agenda

It seems to be necessary to come down from the level of generality used in this survey and to be more concrete. It has to be acknowledged that there is no such thing as a commodity "knowledge" which can be treated as homogeneous at least to the same degree as cars or computers. "Knowledge" is created in various forms, under various conditions and for various purposes, and it looks impossible to determine its properties and its handling in markets or other institutions without specifying the context. So in some sense we are

back at the old and unsolved epistemological question what knowledge is. However, economic considerations along the lines presented above should be helpful. We should look at the type of knowledge we are considering, and Machlup's classification is probably a good starting point. We should look at the technical conditions under which knowledge is produced, e.g. the extent to which it can be modularized, and we should look at the ways in which it can be utilized, commercially and otherwise. And finally, we should keep in mind that economics provides a useful way to look at things, but it needs to be supplemented by the insights of other disciplines as well.

6. References

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